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THE CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE

Twenty-Fifth Meeting, Addis Ababa (Ethiopia), 24 February - 3 March 1981

PEST MANAGEMENT

PROGRESS REPORT BY TAC SECRETARIAT

(Agenda Item 9)

Proposed objectives of the discussion

At its last meeting in Manila, the CGIAR decided to follow the TAC recommendations not to include ICIPE into the system, and to ask the World Bank to act as a secretariat and fiscal agent to a consortium of ICIPE donors; at the same time the CGIAR chiefly requested TAC to make a thorough review of the priority to be given by the CGIAR to pest management.

The provisional and incomplete nature of the attached note is acknowledged: it has been prepared to assist TAC in the discussion of the possible scope and elements of the study requested by the CGIAR. Pages 1 to 5 are of a general information nature; pages 5 to 18 relate to recent activities and build-up, mostly of an international nature; paras 48 to 53 (pages 19-22) refer to possible TAC follow-up action for which the Secretariat would like to receive guidance, specifically on the proposals mentioned in para 53:

either (i) launching a stripe analysis
or (ii) organizing a technical consultation
and
(iii) the preparatory work to be carried out between the 25th and the 26th TAC meetings.

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

February 1981

PEST MANAGEMENT

Progress Report by TAC Secretariat

(1) Introduction

1. The matters of pest management in general and ICIPE in particular have been before TAC since almost the beginning of the system; ICIPE introduced again a request for formal admission in the CGIAR in 1979 which prompted the Group to ask TAC to study again the matter in detail. A TAC mission was launched in April 1980 and upon examination of its report TAC, at its 24th meeting (Lima, Peru, 1-8 July 1980), recommended against the admission of ICIPE, chiefly on ground of its place among the relative priorities of the CGIAR system and factor-oriented research, as well as of its possible complementarity with the commodity programmes of the IARCs.

2. At its recent meeting in Manila (30-31 October 1980), the CGIAR considered the TAC report on ICIPE's candidature for admission into the system; during the long debates on the question the tally of opinions expressed from the floor indicated an almost equal split of preferences pro and against the admission of ICIPE but with a majority of nayes coming from the donors who would have been expected to produce additional resources to ICIPE. The CGIAR Chairman, after an informal consultation with both parties, presented a compromise solution which was accepted. ICIPE would not be accepted into the system, but a consortium of donors to ICIPE would be organized outside the CGIAR system, with the World Bank ensuring its secretariat, serving as its fiscal agent and providing such assistance as may be necessary. The extract from the draft informal summary of the proceedings of the CGIAR meeting indicates that *"there should be a thorough review by TAC of the priority to be given by the CGIAR to insect and pest management. This would include ICIPE's programme and relevant activities at the IARCs as well as examination of possible CGIAR funding of specific programmes of ICIPE, as in the case of WARDA".* Since then, a memorandum dated 9 December, has been circulated from the Director, AGR, World Bank, to the members of the CGIAR on the matter of ICIPE and its consortium of donors. 1/

1/ The World Bank is providing the ICIPE donors group secretariat and proposes that at the meeting of the European donors of the CGIAR (Stockholm, June 1981) or at the next CGIAR meeting, the five-year programme and budget of ICIPE be reviewed together with an outline of the capital development proposals; the World Bank is also prospecting the recruitment of co-sponsors to ICIPE and the idea of conducting in-depth review of ICIPE's activities along the lines of the quinquennial reviews of IARCs.

3. The present note has been prepared by the TAC Secretariat in order to assist TAC in the identification of the elements and the definition of the scope of the study of priorities for international support to pest management research; 1/ it is also hoped that it will assist TAC in deciding what course of action to follow. The tentative, informal and fragmentary nature of the present paper is readily acknowledged. The complexity of the subject would certainly require several treatments, should TAC decide to pursue the matter. The Secretariat looks forward to further guidance. To simplify matters, the present approach deals with crop pest management only.

(2) Background information

(i) General considerations

4. After the end of World War II, the discovery, development and availability of rather cheap and effective synthetic organic pesticides led to a complete change from plant protection based on the use of a combination of control agents to the well known chemical pest control relying almost exclusively on one single factor, synthetic organic pesticides. In the beginning this produced rather spectacular control results, but soon a number of problems arose in the form of the appearance of new pests, the development of insecticide resistant insect strains, the pollution of biotopes and the reduction of useful micro-organisms, animals and insects. This trend was accelerated by the general intensification of agricultural production with the inherent higher inputs and extensive mono-cropping creating generally more favourable conditions for pest development.

5. Some of the problems generated by overreliance on insecticides (outbreaks of new pests) were already recognized in the late 40's. As a reaction to this, emphasis was placed on biological control but in most cases this did not lead to economically satisfactory plant protection. Consequently, specialists devised systems whereby various methods and techniques of pest control could be used compatibly, with minimal reliance on toxic chemicals, and the avoidance of possible side effects in the use of chemicals. 2/ This was the beginning of integrated pest control, the integration of biological and chemical control.

1/ The important contribution of the Plant Protection Service of the Plant Production and Protection Division of FAO to the preparation of this note is gratefully acknowledged.

2/ See FAO/UNEP document "Development and Application of Integrated Pest Control in Agriculture; Formulation of a Cooperative Global Programme", October 1974.

6. There was also in the 70's, greater concern for the protection of the environment and basic resources which led in some cases to the outright prohibition of specific pesticides. In the study made by the US Academy of Sciences, 1/ the first recommendation related to contemporary pest control practices and prospects, reads as follows: *"We recommend that problems internal to chemical pest control technology warrant a high priority effort on the part of concerned agencies to evaluate and then to further the development of alternative technologies. At the same time, attention should be given to institutional and technological means by which present methods can be made more effective until the alternatives are ready to provide substantial relief."* 2/

(ii) Definition

7. The term pest would apply 3/ to all organisms of concern to plant protection disciplines: insects, acarideae, weeds, plant pathogens, nematodes, vertebrates, etc.; in other words, pest would represent any organism or other biotic agent that affects plants or plant products in ways which conflict with human interests. The term pest includes then diseases, as well as weeds, insects and vertebrate or polyphagous pests (rodents, birds, locusts, etc.).

8. The definition of integrated pest control as drawn up by the FAO Panel of Experts on Integrated Pest Control reads as follows: 4/ *"Integrated pest control is a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury".*

9. In the draft report of a conference organized by the International Organization for Biological Control (IOBC), it is stated:

1/ "Pest Control: an Assessment of Present Alternative Technologies", National Academy of Sciences, 1975.

2/ Ibid. Vol. I, page 2.

3/ See Report of 7th Session of FAO Panel of Experts on Integrated Pest Control (1975), and Report of US National Academy of Sciences (see 1/ above).

4/ From "Integrated Pest Control in the Developing World", by L. Brader, Ann. Rev. Entom., 1979.

"Integrated pest management (IPM) which is identical to integrated pest control (IPC) is a crop protection strategy utilizing all suitable techniques and methods which are compatible with economic, ecological and toxicological requirements". 1/

(iii) Economic importance of the problem

10. Due to the complexity and variable nature of pest incidence on agricultural production and of inaccurate or often inexistent statistics, it is difficult to gauge accurately the amount of pesticides used in the world on different crops and the direct and indirect effects of these applications. One report 2/ on the evaluation of crop losses due to pests puts forward the following figures (US$ equivalents based on 1965 values):

Monetary Value of Losses

(in % of potential production)

	due to insects	diseases	weeds	Total	Equivalent of total in billion dollars
Wheat	5	9.1	9.8	23.9	5.8
Rice*	26.7	8.9	10.8	46.4	16.9
All cereals	14.7	8.9	11.2	34.8	34.0
All crops	12.2	11.8	9.7	33.7	71.0
	with polyphagous pests (rodents, locusts, termites, birds)				
id.	13.8	11.6	9.5	34.9	75.0

* Excluding P.R. China

11. In 1970, 90 US firms were engaged in the production of pesticides, and 30 of these produced 80% of the poundage and spent US$ 70 million on pesticide research and development. In 1971 more than one billion pounds of toxic chemicals were used in the world for a value of US$ 3.4 billion.

1/ From "The Future of Integrated Pest Management", Bellagio (Italy), May-June 1980 - Draft Report.

2/ "Plant Protection and World Crop Production" by H.H. Cramer, 1967, Bayer.

In 1971 it was estimated that the total quantity of pesticides used in the USA amounted to about one billion pounds out of which 60% went to agriculture and forestry. This quantity enabled to reduce drastically arthropod borne diseases and avoid agricultural losses which would have amounted to US$ 2 billion. Pesticides used in agriculture were increasingly composed of herbicides which in 1971 represented 46% of the total amount used in agriculture, mostly on corn, cotton and soybean; the largest total insecticide treatment went to cotton, corn, soybean, fruits and tobacco. In 1973 it was estimated that the 1500 basic registered compounds produced by the US manufacturers represented 1.2 billion pounds of material worth US$ 1.34 billion; a quarter of the tonnage was exported. Many basic chemicals were further processed by 1800 pesticide formulation companies which marketed about US$ 800 million of material for agriculture alone. The public sector largely based in the USDA/Land Grant Universities complex spent in 1972 about US$ 120 million on pest control research. 1/

12. In a paper prepared for TAC's attention by FAO,2/ it was estimated that in 1973/74 total expenditures on pesticides amounted to US$ 3 billion, out of which 10% were used in developing countries.

(3) Recent international activities and institutional build-up

(i) TAC

13. During the early years of the CGIAR system, TAC was presented with several proposals coming from UNDP and FAO on the general matter of pest control, particularly at the 5th and 6th TAC meetings (January/February 1973 and July/August 1973 respectively). At the fifth TAC meeting, one paper from UNDP supported by FAO and the Joint FAO/International Agency for Atomic Energy Division called the attention of TAC on a better identification of gaps in pesticide residues research as a first step towards better coordination and accelerated effort in this area; another paper, by FAO, introduced the subject of integrated pest control and emphasized the need to blend chemical pest control with other techniques; the paper envisaged inter alia a network of cooperative multi-country research projects on this subject. At the sixth TAC meeting, a FAO paper proposed a worldwide coordination of research on

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1/ From Report of US National Academy of Sciences (see 1/ page 3).

2/ "International Research Needs on Control of Pests in Agriculture" Draft FAO Statement for the 5th TAC Meeting.

diseases caused by Fusarium spp; another invited the Committee to consider a worldwide coordinated programme of research on horizontal resistance to wheat diseases. On all the above accounts the reaction of TAC was negative and the general matter of plant pest control was considered to be associated with, and an integral part of, the primary commodity research centres. Over the different meetings the matter of ICIPE only was being brought up at intervals (for further details, reference is made to Chapter III of the TAC mission report to ICIPE - Review of TAC and CGIAR discussions on ICIPE, pp. 13-14.).

14. The question of plant pest and disease management and control was mentioned by TAC in its study "TAC Review of Priorities for International Support to Agricultural Research" (AGD/TAC:IAR/79/1 Rev.1). 1/

15. In reviewing factor-oriented research ("Factor-Oriented Research under the CGIAR", AGD/TAC:IAR/80/5), 2/ TAC made reference to the above and concluded: *"TAC has identified water management, and plant pest and disease physiology, ecology, management and control as high priority areas for consideration of possible new institutional arrangements under CGIAR auspices. Plant nutrition will also be the subject of an analytical paper to be commissioned by the TAC".*

16. At its 24th meeting, TAC recommended against the admission of ICIPE 3/ for reasons briefly mentioned in para 1 above.

(ii) FAO involvement in integrated pest control

17. In 1965 FAO organized the first worldwide Symposium on Integrated Pest Control (IPC). The Symposium reviewed progress in IPC and strongly recommended that FAO take a leading role in the further development of IPC. As a first step the FAO Panel of Experts on IPC was established in 1966 to advise the Director-General on the activities to be pursued by the Organization. Normally the Panel is meeting annually; it has continuously insisted on the direct involvement of FAO in field programmes. Consultancies to various countries were organized and country projects were developed and implemented, e.g. in Nicaragua for cotton growing;

1/ See Annex I.

2/ See Annex II.

3/ See Draft Report of the 24th TAC Meeting (AGD/TAC:IAR/80/28), paras 171-182, pp. 51-54.

in Greece for olive production and in Western Samoa for the control of the coconut beetle.

18. However, the Panel felt that a more permanent framework for active development of field activities was needed. It proposed in 1974 the FAO/UNEP Cooperative Global Programme for the Development and Application of Integrated Pest Control in Agriculture. This programme is being implemented from 1975 onwards. The objectives are to develop IPC through the exchange of information, demonstration plots, training, applied research and assistance to extension service activities. Cotton, rice and sorghum/millet were selected as priority crops and inter-country programmes were to be developed for these crops. Such programmes should ensure maximum involvement of the countries concerned and through complementary activities in each of them lead to the rapid development of effective field programmes. The African inter-country programme for cotton is being implemented since December 1978 mainly through initial action in Sudan. Proposals have been elaborated for Egypt. The Near East inter-country programme for cotton is being implemented since June 1978. Field activities are carried out in Syria and Pakistan. Contacts are maintained with Turkey, for which a project proposal has been developed. The Latin American inter-country programme for cotton will start in Colombia in early 1981. The funds to cover these cotton programmes are currently coming from UNEP, the Netherlands, UNDP and FAO Technical Cooperation Programme (TCP).

19. A programme for integrated pest control for basic food crops (sorghum/millet mainly) has been elaborated during the past three years for eight Sahelian countries. The first phase of five years' duration is financed by USAID (US$ 25 million); field activities started in 1980. The programme for rice in South and South East Asia has been implemented since early 1980; financial support has been received from ADAB. The preparatory work for this programme was financed by the Australian Freedom from Hunger Campaign. The FAO Panel of Experts on IPC is the advisory body for these programmes. Over the past years FAO has published "Guidelines for Integrated Pest Control" in cotton, rice, sorghum and maize respectively. The preparatory work for this was mainly done by the Panel.

20. FAO's Plant Protection Programme is involved in various other activities which are all aimed at assisting member countries in strengthening their plant protection capabilities. This includes:

- the reduction of post-harvest losses, which forms an integral part of the FAO Action Programme for the Prevention of Food Losses;
- the control of plant diseases, within this activity major emphasis has been given to the more accurate assessment of crop losses and the development of crop

varieties possessing so-called horizontal resistance to disease organisms; various international expert groups have been organized to study and provide advice on specific disease problems, currently a close cooperation is established with the International Society for Plant Pathology (ISPP);

- plant quarantine, the work undertaken is largely guided by the administration of the International Plant Protection Convention (IPPC) which determines the rules and regulations covering international transports of plant material. The IPPC also provides for collaboration between various countries; under it three regional FAO Committees have been established, i.e. the Plant Protection Commission for Asia and the Pacific, the Near East Plant Protection Commission and the Caribbean Plant Protection Commission. Other Regional Organizations established in accordance with the IPPC are the European Plant Protection Organization (EPPO), the Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA), the Inter-African Phytosanitary Council (IAPSC) and the North American Plant Protection Organisation (NAPPO);

- agricultural entomology, the activities related to IPC have been mainly developed within this group. In addition the problems involved with the development of pesticide resistance have been continuously reviewed. Advise for this was provided by the FAO Panel of Experts on Pest Resistance to Pesticides. In recent years increased attention has been given by the Panel to resistance to fungicides;

- pesticides, this covers a number of activities such as: the preparation of recommendations for maximum pesticide residue limits in food through the Joint WHO/FAO Annual Meeting on Pesticide Residues; the elaboration of pesticide specifications with the help of the FAO Panel of Experts on Pesticide Specifications, Registration Requirements and Application Standards; and the international harmonization of pesticide legislation, assisted again by the above-mentioned Panel. With respect to pesticides close contacts are maintained with the Codex Alimentarius, the International Union of Pure and Applied Chemistry (IUPAC), the Collaborative International Pesticides Analytical Council (CIPAC) and the Pesticides Industry;

- weed management, assisting countries in reducing losses by weeds. Close collaboration with various weed scientists is ensured through the International Weed Science Society (IWSS).

21. Special mention should be made of FAO's coordinating role with respect to the control of migratory locusts, in particular the Desert Locust. This includes field research on locust ecology and most effective control means and techniques, the coordination of surveillance and forecasting of outbreaks (the latter recently with the help of remote sensing techniques) and the organization of international assistance. Countries falling within the Desert Locust invasion area are almost all members of the FAO Desert Locust Control Committee which advices on the various activities undertaken. This work is further supported by regional organizations and commissions, such as the Desert Locust Control Organization for Eastern Africa (DLCOEA), the Organisation Commune pour la lutte Anti-Acridienne et Anti-Aviaire (OCLALAV), the three FAO Regional Commissions for Controlling the Desert Locust respectively in the Near East, South East Asia and North West Africa.

22. Following the 1977-79 Desert Locust upsurge FAO has launched with UNDP funding the Action Programme for Improved Plant Protection. This programme aims in particular at strengthening plant protection infrastructures in various countries, in the first place in those falling within the Desert Locust invasion area. The FAO Committee of Experts on Pest Control is the advisory body to the programme,and both recipient countries and donor agencies are represented in the Committee. Firstly an inventory will be made of the current plant protection activities in each country, this, together with the information on the agriculture in the country concerned, will serve to prepare a plant protection development plan. This plan will then allow to prepare project proposals for plant protection development and to assign priorities to these proposals.

23. Within the FAO/International Agency for Atomic Energy (IAEA) Joint Division part of the efforts are devoted to integrated pest management. Most of the work is carried out through research contracts with Institutes in developing and developed countries. These contracts concern breeding for pest resistance, the study of the fate of pesticide residues in food and the environment and the use of radioisotopes for the study of the ecology of different plant pest species.

(iii) IARCs

24. The following notes on the present staffing and activities of the pest control programmes of some major IARCs have only been based on recent annual reports and/or highlights, and are likely to contain

mistakes and omissions. The IARCs concerned are evidently the best placed to indicate the present achievements and trends of their pest control or management programmes and should be consulted in due course.

25. IRRI [1/] has a staff of 34 resident entomologists and 23 plant pathologists (this would include principal scientists, scientists, associate, assistant and visiting scientists, senior research assistants, research assistants and aides). With the outposted staff, the total would be 35 entomologists and 25 plant pathologists, making a grand total of 60 staff members engaged in pest control.

26. Breeding for resistance against diseases is given high priority and is based on horizontal and vertical or monogenic resistance; *"monogenic resistance, when it is effective, provides complete protection from disease. Horizontal resistance is not effective when epidemics occur, but it can provide protection against loss from disease in non-epidemic conditions"* 2/. Vertical resistance has been developed into a race prediction/gene rotation breeding system. Screening plays an important role in identifying sources of resistance; specific breeding methods for different diseases have been developed.

27. Sources of resistance to some of the major insect pests have been identified; studies on insect biotypes have been made, causes of plant resistance to insect attacks are being actively explored with the identification of several plant chemicals; an excellent example of this is the Brown Plant Hopper (BPH), which is the object of studies regarding its ecology, dynamics and timing of control by chemicals; moderate plant resistance to BPH is thought to make the insect more susceptible to predators; in general chemicals are used when host resistance to the disease transmitted by the insect or the insect itself is weak or non existent; integrated pest management is being tried out. Various studies on weed management and the best use of herbicides are also being carried out at IRRI.

28. ICRISAT [3/] staff includes 18 pathologists, 8 entomologists and 1 plant quarantine officer, making it a total of 27 officers (out of whom two outposted) engaged in pest control. On all mandated crops screening and breeding for host resistance to diseases and insects are conducted; the dynamics and biology of shootflies particularly important for sorghum are studied; physiology studies are also part of the general studies conducted on plant resistance to pests; the monitoring of pest population

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1/ From "Research Highlights 1979".
2/ Ibid, pp. 27-28.
3/ Based on 1979 Research Highlights and 1978/79 Annual Report.

and natural enemies dynamics is carried out in the case of pigeonpea and chickpea; the role of insects in the transmission of groundnut virus diseases is being investigated; the role of different crop sequences on incidence of insect number and the rapport between crop practices and parasitism are studied.

29. IITA [1/] staff includes three weed scientists, ten entomology and nematology specialists, and 14 phytopathologists, making it a total of 27 staff members (including four outposted ones) engaged in pest control. The screening and breeding of plant material for resistance against insects and diseases is conducted on the different mandated crops; viruses are important in the root/tuber crops ; entomological research is conducted on two new insect pests, the green spider mite and the cassava mite (mealy bug), which are important in cassava production; research is also conducted on anthracnose and bacterial blight (cassava) and nematodes (cocoyam); breeding for insect and virus resistance is carried out on cowpea and resistance to bacteria on soybean; resistance to weevils is part of the pulses and sweet potato programmes and resistance to viruses and stemborers of the maize and rice programmes.

30. CIAT staff includes 17 entomologists (1 outposted) and 20 plant pathologists (1 outposted), making a grand total of 37 specialists engaged in pest control. [2/] Screening and breeding for resistance against diseases (among others viruses, rust, bacterial blight and anthracnose) and insects (leafhoppers and pod weevils) are part of the bean research programme; a comprehensive publication on "Bean Production Problems" (CIAT 1980) describes in detail the different diseases and insects causing damage to beans and records the control methods useful in each case. Research on cassava pest control includes the resistance to mites, environmental studies related to resistance to bacterial blight and Sphaceloma fungus responsible for superelongation and the use of tissue cultures; particular attention has been given to biological control of pests, using both predators and parasites; weed control - considered as the major single cost factor of cassava production - is studied using chemicals as well as crop practices. An all embracing publication "Cassava Pests and their Control" (CIAT 1978) reviews the different insect pests attacking cassava and their methods of control. As regards rice particular attention is devoted to blast disease (Pyricularia sp.) and weed control.

31. CIMMYT. [3/] Breeding for pest resistance is an integral part of the research programme, particularly resistance to the three rusts,

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1/ From IITA 1979 Annual Report.

2/ From CIAT Report 1980.

3/ From CIMMYT Review 1980. It is not possible to identify the sizb of the scientific staff assigned to pest control research.

with the International Bread Wheat Screening Nurseries being the major mechanism to identify and distribute lines with broad resistance; specialized nurseries take care of identifying resistance against Septoria and Helminthosporium. As regards durum wheat, increased attention is being given to resistance to stem rust and to Fusarium; in barley, breeding is oriented towards resistance to Rhynchosporium, stripe rust and barley Yellow Dwarf Virus; in triticale towards resistance to barley Yellow Dwarf virus and Septoria. In the maize programme, entomologists and pathologists are also part of an interdisciplinary team which tries to develop resistance to insect and disease, rising inoculum and artificially reared insects; collaborative research between CIMMYT and six national programmes aims at developing increased resistance against downy mildew, maize streak virus and corn stunt.

32. WARDA [1/] has a staff of three plant pathologists, 4 entomologists and 2 weed scientists, making it a total of nine scientists working on pest control; most of them are working in the four special projects WARDA has in mangrove swamp rice (Sierra Leone), irrigated rice (Senegal), floating and deep flooded rice (Mali) and upland rice (Ivory Coast). Besides screening for resistance to pests, the WARDA specialists have included the study of insecticides and herbicides in coordinated variety trials, and are doing research on rice stemborers, disease and weed control in the above four locations.

33. ICARDA [2/] screens genetic material for resistance against rusts and other cereals diseases particularly in barley and durum wheat; a programme for breeding resistance to insect pests has been started and will be further developed; a programme is being made for breeding resistance against pests in the mandated pulses, chickpea, broad bean and lentil.

34. CIP [3/] has a Headquarters research staff of 5 entomology and nematology specialists, 6 pathologists, complemented by one outposted entomologist, 4 scientific associate-pathologists, four scientific assistants on entomology and nematology, and 12 on pathology; this would make a total of 10 entomologists/nematologists and 20 pathologists. Four research thrusts are devoted to the control of fungal diseases, bacterial diseases, virus diseases and nematodes and insect pests, respectively.

(iv) ICIPE [4/]

35. The programme "Bases of plant resistance to insect attack" is concentrated at the Mbita Point field station in Kenya and at IRRI.

1/ From 1979 Annual Research Report.
2/ From 1978-79 Research Report. Details about staff composition are not indicated.
3/ From 1979 Annual Report.
4/ From TAC Mission Report and 1979 Annual Report.

In collaboration with an ICIPE specialist, IRRI is studying the genetic and physiological mechanisms responsible for the breakdown of resistance by the formation of new Brown Plant Hopper biotypes and the dynamics of BPH populations. At Mbita Point, the behavioural and physiological relationships between insects -mainly stemborers- and resistant varieties are studied; some insects have been mass reared. The programme has one outposted scientist (IRRI), one scientist, one postdoctoral fellow and three technicians resident at Mbita Point; besides, one agronomist screens maize, sorghum and cowpea cultivars for resistance to borers, using artificial infestation techniques. The crop borer/sorghum shootfly programme studies the physiology and ecology of some insect pests with four scientists, two associate scientists and eight technicians. Two other programmes (grassland termites and African army worm) are related to agriculture but of less general importance than the above two programmes. It is difficult to suggest from the above what parts of these programmes, if any, CGIAR could support and finance. The four insect pests retained now by ICIPE as target species: Maruca testulalis (on cowpea), Chilo partellus (on maize, sorghum and millet), Atherigona soccata (on sorghum) and Maliarpha separetella (on rice) are all studied rather intensively by existing IARCs. Possibly a clear picture of possible CGIAR support to ICIPE would come from a global view of both the crop and animal pests aspects of the ICIPE programme, from interchange of ideas with IARCs and from a possible overhaul of ICIPE's present programme. In this respect it should be noted that recently discussions have been held between ICIPE and FAO in order to broaden the institute's current activities into a real integrated pest management programme. The preliminary results have been summarized in a draft paper for further discussion.

(v) Others

36. Some bilateral programmes and national institutions are quite active in the pest management field, but are too numerous to have been mentioned in detail here and the list would have been incomplete. However, particular mention might be made at this stage of the following that provide assistance to developing countries:

- Belgium: bilateral and multilateral aid programmes;
- Canada: CIDA technical assistance programmes;
- France: ORSTOM, INRA, GERDAT and the Ministry for Cooperation;
- German Federal Republic: The German Agency for Technical Assistance (GTZ) together with the Biologische Bundes-

Anstalt, Plant Protection Services of the states (Länder) and different universities;

- Netherlands: Agency for International Technical Assistance, often in collaboration with the Agricultural University at Wageningen and various Agricultural Research Institutes;
- UK and Commonwealth Agricultural Bureaux: The Overseas Development Administration, the Centre for Overseas Pest Research, the Tropical Products Institute, the Commonwealth Institute for Biological Control, the Commonwealth Mycological Institute and the Commonwealth Institute of Entomology;
- USA: USAID and various programmes of USDA and the Land Grant Universities;
- Australia: the Australian Development Assistance Bureau partly through cooperation with the CSIRO, State Institutions and Universities.

37. Most of the research and development activities in Europe and the Mediterranean Area are coordinated by Working Groups of the International Organization for Biological Control (IOBC). The European Economic Community (EEC) has decided to include biological and integrated pest control among the ten topics which will be the subject of research co-ordination; the Organization for Economic Cooperation and Development (OECD) steering group on "pest control under small farmer conditions in developing countries" presented its report to a Development Assistance Committee meeting in 1978 during which the notion of Integrated Pest Management was supported and a strong liaison role by FAO advocated.

(4) Outlook

38. Due to the sheer size and economic importance of damages and crop losses caused by pests affecting food crops, any institution having among its objectives to assist in meeting the food needs of a growing world population will have to give pest management its due place.

39. Agricultural production is increasing continuously and this is accompanied by a more than proportional increase of the use of pest control means. For example, the pesticide market has multiplied about five-fold in the last 25 years, and will probably double in the coming 15 years. The reason for this increase is of course the fact that these control means often provide effective protection against pests, but this development does not demonstrate that our crops have become healthier; on the contrary we need to augment regularly our control efforts to overcome increased pest problems. It is quite evident that the combined

costs of crop losses and the control efforts, expressed as a percentage of the production costs, are increasing continuously. 1/

40. The above conclusion is closely supported by the following two examples:

- In the USA losses due to agricultural pest are now higher than ever before, notwithstanding the considerable input in pest control means and research; 2/
- In rice growing a situation has now been reached where the International Rice Research Institute states that next to water, pests and diseases have become the major constraint to rice production. 3/

Consequently, the conclusion seems justified that the considerable efforts made so far have not led to the development of plant protection methods which result in a real improvement of the plant health situation - a goal that can only be achieved if losses are smaller while at the same time less plant protection inputs are required. This particular aspect of plant protection should be fully acknowledged when providing advice on the transfer of plant protection techniques, and every effort should be made to provide solutions that allow real improvements especially in the resource poor countries. The integrated pest management approach will lead to such more permanent and real improvements in plant health.

41. It is fully recognized that the implementation of operational integrated plant protection programmes in developing countries is not just a question of simple transfer of results from other areas, as such programmes require a certain amount of local research and organization. However, sufficient knowledge has gradually become available to identify generally applicable principles and control methods. Thus, there is scope for the initiation of an integrated plant protection approach that can be modified and improved as further results become available. It is often not realized that some of the best practical examples of integrated plant protection are found in countries like China, Chile, Egypt and

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1/ This paragraph and paragraphs 40 to 45 are extracts from L. Brader's paper "Transfer of Integrated Plant Protection Techniques to Developing Countries", Proc. IOBC/WPRS International Symposium on Integrated Control in Agriculture and Forestry, Vienna, 8-12 October 1979.

2/ Pimentel, D., 1978. Socio-economic and legal aspects of pest control. In: Pest Control Strategies, pp. 55-71. Ed. E.H. Smith & D. Pimentel. New York: Academic Press.

3/ IRRI (International Rice Research Institute), 1979. "Long range planning committee report", Los Baños, Philippines, 85 pp.

Malaysia. It was mainly common sense and a pragmatic approach that led to quick results in these countries. Complex techniques were not used, but the basic principle in all cases was to allow naturally-occurring biological control elements to again play an effective role. This was done through the appropriate choice and integration of pesticides. Nevertheless, it is often noted that integrated plant protection is a very complex matter which requires a high level of technical skills and strong administrative support. It seems that this conclusion is all too frequently based on the situation encountered in the Western World, where on many occasions it has become a subject of very detailed research and encompassing other activities which are not always of direct relevance to the practical application. The above cited examples show that effective programmes may be implemented without further lengthy and detailed preliminary research. The basic principles of the approach are not necessarily more complex than, for example, the calendar-scheduled applications of pesticides, especially when one wants to forestall and foresee the various short- and long-term consequences.

42. A brief review of some of the components of integrated plant protection that best lend themselves to transfer from one system to the other may further clarify the above. Pest surveillance is the backbone of the system and rather simple pest observation techniques may be developed for this. The information obtained on pest occurrence has to be complemented with the economic damage threshold in order to issue a warning for the execution of a control operation. In the beginning, the damage threshold is mainly established on the basis of information already available on the economic importance of the pest problem concerned. Refinements may be made later after further research results become available, and the pest surveillance system may eventually develop into a rather complex pest forecasting system. Trapping with the help of sex pheromones is one of the most promising techniques developed in recent years. It has general applicability and considerably improves and facilitates the surveillance of certain arthropod species. The identification and production of synthetic pheromones could be a very useful tool for many developing countries. The obvious advantage over, for example, light traps is the selectivity of the catches and consequently the relative easiness of analysing them.

43. Pesticides are the principal artificial tools in the system and their better timing and choice will permit the greatest advantage to be taken of existing compounds. The use of products that are known to have a broad spectrum contact action against parasites and predators will be avoided. Application in itself can also help in achieving a certain degree of selectivity, the ultimate aim being the protection of naturally-occurring parasites and predators. More selective compounds should therefore be introduced when they become available at competitive prices, and should also include entomopathogens and mass-produced parasites and

predators. In this respect, special mention might be made of the egg parasite Trichogramma. The basic research carried out in developed countries on simplified rearing techniques, and the identification and selection of various ecotypes, opens the way to excellent prospectives for the more intensive use of this egg parasite in developing countries. The parasite is now produced and used for the control of lepidopterous pests in countries such as China, Colombia, El Salvador, France, Mexico and the USSR.

44. The suitability of the crop as a host for the different pest species is one of the major biotic factors in determining the level at which population levels will fluctuate. Less susceptible crop varieties are now produced on an increasing scale through selection and breeding. The value of this is generally well recognized as an inexpensive means of plant health improvement. Host-plant resistance research is well suited to developing countries, but it should be noted that this may be a rather time-consuming process. Moreover, the new varieties require careful evaluation for other production characteristics. The stability of resistance needs to be closely followed and a deliberate policy for the growing of these varieties should be considered, in order to avoid the development of new biotypes of physiological races which may suddenly cause large-scale damage. Agronomic practices have a significant influence on pest development and it is essential to understand the various mechanisms involved. This would permit certain adjustments to be made within the limits of the socio-economic conditions. For example, the annual cycle of pest organisms in most regions is primarily determined by climatic conditions. Thus, changes in sowing dates of annual crops may lead to the avoidance of a partial pest attack.

45. The above elements are the basis for a gradual introduction of integrated plant protection programmes best suited to the local conditions. As already mentioned above, the first step consists in the implementation or strengthening of a pest surveillance system, followed by the judicious use of available control means and the introduction of more selective techniques as they become available.

46. The report of the Conference of "Future of Integrated Pest Management" 1/ mentions that progress in the implementation of IPM in developing countries has been slow; likewise in Europe IPM is still mainly limited to fruitcrops, and to greenhouse crops; in the US there is large-scale application of IPM on cotton and sorghum and, more regionally, on apple, alfalfa and soybeans. Constraints are seen to be: the availability of advisory services; economic competitiveness of chemicals, and the often

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1/ See footnote 1/ page 4.

high cost of alternative pest control agents; the lack of adequate methodology for the estimation of the cost/benefit ratio of IPM programmes as compared to conventional ones; the financial risk in passing from one system to another, considering that the producer is more preoccupied by short-term than by long-term considerations; and the difficulty in quantifying the risks and costs involved. In resumē, a step-wise approach is recommended and the need for collaborative effort stressed.

47. Several subjects for further research have been mentioned in the relevant reports and papers produced on the subject by FAO; the US National Academy of Sciences report mentions also several topics and so did the two OECD meetings reports mentioned above. A comprehensive study and rating of these priorities and objectives would take time and require appropriate expertise. A brief list is tentatively mentioned hereunder:

(a) Improvement of basic knowledge: general inventory and appraisal methods of crop losses; better understanding of the ecology and biology of pests; identification and quantification of biological and physical parameters of particular pest systems; recovery mechanisms of plants attacked by pests; identification and inventory of parasites and predators of insect pests.

(b) Further research on population dynamics of various pest species; host plant resistance; attractants (pheromones in particular).

(c) Improvement of information: registration of pesticides under use; registration of microbial and other selective agents and chemicals; testing and trial procedures to monitor new chemicals in particular their side effects on useful organisms.

(d) Treatment of information and research strategy: modelling of pest dynamics; descriptive models of crop/pest ecosystems; long-range forecasting procedures.

(e) Applied research: mass production techniques of pest parasites and predators; economy and timing of use of chemicals; establishment of pilot research schemes on integrated management of key pests.

(f) Extension of the various research approaches to disease and weed management problems.

(g) Farming systems research: the place of integrated pest management in the major crop production systems is a study in itself.

(5) Possible course of actions by TAC

48. IARCs have been putting so far major reliance on breeding for resistance to diseases and pests, quite fittingly for a system which originated, in part, to the need to enlarge screening of wheat germplasm for finding rust-resistant varieties. It is also a "clean" pest control method, particularly accessible to small farmers as it may not require further inputs. There is however a growing tendency among IARCs to complement the elaborate system of international nurseries by including other methods of control: IRRI is comparing complete insect protection with the IPM approach and the first conclusions are that, although returns are higher with IPM, they are not such yet to induce farmers to shift from one system to another; experiments are however continuing; meanwhile intensive studies are made on the detection of plant chemicals for pest control and on the biology of one of the major insect pests. ICRISAT is looking into insect traps and pheromones attractants and the combined use of resistant varieties and chemicals. IITA is considering the integrated control of cowpea pests and CIAT has done a complete coverage of the different control methods of bean and cassava pests.

49. CIAT has probably explored, more than any other centre it seems, an integrated approach to the pest problem. In the case of Phaseolus bean, one of their reports states *"Control strategies feasible for these growers (farmers with small land holdings) may be restricted to those strategies which do not require large cash inputs, hence breeding for resistance may be the most desirable alternative available ... Stability of resistant materials can be improved with an integrated control strategy consisting of resistance, cultural practices, chemicals and clean seed production for those diseases in which resistance does not confer immunity to infection. This integrated control strategy will need to be adapted to specific regional problems."* 1/ In another publication 2/ CIAT specialists examine inter alia the reasons which militate for a biological control of cassava insect pests and come to the conclusions that an integrated control programme should be based on biological control and host plant resistance.

50. Currently various structures exist for the further development and application of integrated pest management, these include:

- with respect to research, the various national research institutions and the international agricultural research centres. 3/ It may be expected that these activities will gradually be further expanded as the overall interest in IPM is steadily growing;

1/ In "Bean Production Problems", CIAT, Jan. 1980.
2/ In "Cassava Pests and their Control", CIAT, Nov. 1978
3/ ICIPE could be added to this list.

- with respect to application, the various national plant protection services and other institutions directly involved with agricultural production improvement. For the developing countries the FAO/UNEP Cooperative Global Programme for the Development and Application of Integrated Pest Control in Agriculture seems a suitable structure.

The above mechanisms provide an adequate framework through which IPM may be promoted and implemented. The major constraints to further development are in particular insufficient numbers of adequately trained manpower, lack of extension services, inadequate political support and insufficient international funding (see also para. 46).

51. At this stage there is no need for the preparation of comprehensive reports. The following publications do provide a very complete picture of the current state of the art and the implementation constraints:

- FAO 1975. The development and application of integrated pest control in agriculture. Formulation of a cooperative global programme. Rome, FAO, 42 pp.
- Reports of the Sessions of the FAO Panel of Experts on Integrated Pest Control. FAO, Rome.
- L. Brader, 1979. Integrated pest control in the developing world. Ann. Rev. Entomol. 24, 225-54.
- D.G. Bottrell, 1979. Integrated Pest Management. Council of Environmental Quality, Washington, D.C. 120 pp.
- IOBC/WPRS, 1980. Proceedings of the IOBC/WPRS International Symposium on Integrated Control in Agriculture and Forestry, Vienna 8-12 October 1979. Ed. K. Russ, Federal Institute of Plant Protection, Vienna.
- IOBC, 1981. The future of integrated pest management (in press).

With respect to the CGIAR, however, it might be most productive to compare the relevant experience and approaches of the IARCs and to draw up recommendations for more specific involvement of CGIAR in IPM.

52. It is therefore suggested that a full interchange of views and experience between interested parties would assist TAC in formulating recommendations to the CGIAR. FAO has a wide and broad experience in the different aspects of pest control; eight IARCs (IRRI, ICRISAT, IITA, CIAT, CIMMYT, WARDA, ICARDA, CIP) have considerable experience in the in-depth study of the plant protection aspects of eight cereals (bread and durum wheat, barley, triticale, maize, sorghum, millet, rice), eight pulses (chickpea, groundnut, pigeonpea, cowpea, soybean, lentil, broadbean, phaseolus bean), and five root/tuber crops (potato, cassava, sweet potato,

yam, cocoyam), as well as some forage plants. This is being done by 190 specialists at IRRI, ICRISAT, IITA, CIAT, WARDA and CIP, a figure to which should be added the specialized staff of CIMMYT and ICARDA. The IARCs could certainly have some elaborate views on the future role of pest management and so should FAO, developing countries and specialized institutions.

53. The operational details of possible TAC actions could be the following:

(a) Establishment, after adequate consultation with IARCs of a stripe analysis of pest management as viewed by selected IARCs, selected developing countries, FAO and selected specialized institutions, including ICIPE. This would be effected by a roving team of consultants with the production of a report. As usual in these cases, the report might be influenced by the choice of the consultants and their bias. It would be necessary therefore that their draft report be reviewed by a larger audience, possibly by convening a workshop with a wide range of specialists (from the IARCs, FAO, bilateral programmes, developing countries programmes, etc.). The difficulties in arranging a very elaborate schedule of travel and meetings should be considered here. The draft report of the consultants could be revised according to the reactions of the workshop and then those of the 27th TAC (March 1982) and submitted again at the 28th TAC meeting (June/July 1982) before presentation to the CGIAR;

or

(b) Organization of a technical consultation which would chiefly group commodity-oriented IARCs personnel, FAO specialists, scientists from appropriate institutions, ICIPE, developing country representatives and TAC/CGIAR interested members; the objectives would be to compare the experience gained in pest control research; to indicate ways to improve the situation and the scope and objectives of a more specific involvement of the CGIAR in these efforts. This second solution would seem to enable a more open and fruitful exchange of ideas and experience and could be preferred by specialists; it would also be conducive to a more active collaboration of the participants and participating institutions in the preparation of working documents. The report of this consultation would enable TAC to formulate recommendations to the CGIAR.

(c) In both the above cases some preparatory work will be required between the 25th and 26th TAC; in the first case terms of reference will have to be prepared; in both cases contributions from the IARCs should be sought; as a first step it is suggested to have them review and comment upon the present paper which could then be redrafted and serve as a basic working paper for either the consultants (stripe review) or as a preparation for the technical consultation. TAC may then wish to reserve its final decision regarding the choice of one of the above two alternatives until the 26th TAC, at which time the comments of the IARCs would have been received and could be further discussed with the Centre Directors.

ANNEX I

Extract from

TAC REVIEW OF PRIORITIES FOR
INTERNATIONAL SUPPORT TO AGRICULTURAL RESEARCH
(AGD/TAC:IAR/79/1 Rev.1)

Plant pest and disease management and control

"100. The control of avoidance of damage and losses in plants due to pests and diseases is another important factor applying to all commodity crops. The production of new varieties and their wide distribution have often selected and led to increases in pest biotypes and strains of pathogens that sometimes increase the difficulties of present control strategies.

101. TAC recognizes the following topics that require increased efforts for the benefit of international agricultural research.

(a) New varieties (or plant protective chemicals) may disturb pest or pathogen populations, with the potential production of an infinite number of biotypes, some of which may be unusually damaging.

(b) TAC recognized that the serious hazards of introducing exotic organisms or new biotypes must conflict with the need to avoid delays in the collection and exchange of seeds and planting material. The responsibility for approval lies with host governments but not all can easily meet the heavy requirements placed by the IARCs. Because some of the pests and pathogens are little known or completely unrecognized, there is a need for specialists study backed up by the modern facilities within IARCs to collaborate with national programmes in the safe and speedy discharge of these heavy responsibilities.

(c) Stability of crop yields is a major aim which may be inhibited by fluctuations in pest numbers, such as result from the appearance of new biotypes or the chemical destruction of natural enemies as well as pests. The most attractive and cheapest methods of control could be through resistant varieties or the balance of natural enemies. However, some resistance mechanisms quickly lead to the selection of aggressive biotypes and biological control agents are notoriously difficult to manipulate, although the introduction of natural enemies

has sometimes been helpful. TAC strongly supports continuing efforts to breed varieties with durable resistance. It also supports increased study of pest and disease management through an understanding of the ways in which pest epidemiology is affected by crop husbandry, weather and ecological and physiological factors. Furthermore, there is a need to improve understanding of the basic mechanisms of plant resistance and their manipulation but TAC recognizes that this will require collaboration between centres and other laboratories competent to do the work, perhaps by contract and in developed as well as developing countries. 1/ TAC supports the need to integrate all compatible methods of pest control that are feasible and economic in the LDCs.

(d) Integrated control involves the use of all possible controls including chemicals. Plant protective chemicals offer the fastest response to unexpectedly severe pest and disease attacks and hence to achieving crop stability. The chemical industry is constantly producing new classes of chemicals (e.g. downward translocated systemics) which require independent assessment and research on modes of application and action before introduction on crops in the LDCs.

1/ The development of reference laboratories for major pest and diseases may also need special consideration."

ANNEX II

Extract from "Factor-Oriented Research under the CGIAR" (AGD/TAC:IAR/80/5)

"26. Research on plant pest and disease physiology, ecology, management and control has been accorded high priority by the TAC. This is a major factor under intensive consideration by all the IARCs concerned with crop production. ICIPE, concerned with fundamental aspects of insect physiology and ecology, has applied for inclusion within the CGIAR and this has been referred to TAC for advice. As will be considered under a separate agenda item, TAC proposes to send a team to ICIPE in April 1980 to examine this question. Terms of reference and a tentative list of questions for the team to consider have been drafted. The respective roles and relative complementarity of ICIPE and of the other crop-oriented IARCs will need to be examined. The team's findings will be on the agenda for TAC consideration at its 24th meeting.

27. The TAC has not, as yet, considered whether or not there are specific phases of disease physiology, ecology, management and control beyond those being addressed, or appropriate for attention by existing IARCs which would justify additional attention by the CGIAR.

36. The TAC has identified water management, and plant pest and disease physiology, ecology, management and control as high priority areas for consideration of possible new institutional arrangements under CGIAR auspices. Plant nutrition will also be the subject of an analytical paper to be commissioned by the TAC."

Extract from the "Report of the 23rd TAC Meeting" (AGD/TAC:IAR/80/18)

"103. After further deliberation, and taking into account the records of its discussions as presented above, TAC concluded that a paper on factor-oriented research for the consideration of the Group is not needed at this stage and could undesirably highlight what it regarded as an artificial and unnecessary classification for the identification of specific areas for new initiatives by the Group. TAC recommended that the records of its discussion as given in the minutes of this meeting be used instead to convey its views on the subject to the CGIAR. The Committee reached this conclusion in view of the fact that (i) three existing Centres are wholly centered on factor-oriented research already, (ii) that such research is an important component of many of the other Centres, (iii) that several new initiatives under consideration by TAC fall in this category and (iv) that its discussions on institutional alternatives have already resolved that each proposal should be considered on its own merit and without preconceptions as to format or type of research involved."